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Smart Dustbin for Household Using Internet of Things (IoT)

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Abstract

This article, titled "Smart Dustbin for Household Using Internet of Things (IoT)", introduces an innovative solution to manage household waste effectively. In today's fast-paced world, many individuals find it challenging to dispose of garbage regularly due to busy schedules. This IoT-based system aims to address this issue by employing sensors and connectivity to monitor the fill-level of dustbins in real time. By utilizing ultrasonic sensors and microcontrollers like the ESP32, this system accurately detects and measures the level of waste inside the dustbin. When the dustbin reaches its capacity, the system sends alerts to users or authorities via mobile apps or web interfaces. This proactive approach not only ensures timely waste collection but also prevents overflow and the associated environmental hazards. The implementation of IoT technology in waste management systems not only enhances efficiency but also promotes a cleaner and healthier environment. It minimizes the manual effort required for monitoring and managing garbage, thereby optimizing municipal resources and reducing operational costs. Future enhancements could include integrating artificial intelligence algorithms for smarter waste segregation and optimizing collection routes based on real-time data analytics. Such advancements promise to further improve the effectiveness of urban waste management, contributing to sustainable and smart city initiatives. This smart dustbin system integrates an identification system, an automated lid system, a display system, and a communication system. Arduino Uno serves as the central microcontroller to coordinate these components. Sensors are employed for identification and to measure garbage levels. The system enables continuous monitoring of waste status within the bin, displaying the fill percentage on a liquid crystal display. For communication, a Global System for Mobile Communications module is utilized. This module notifies the relevant authorities when the bin reaches capacity, prompting timely waste collection.

Keywords: Smart dustbin, internet of things (IoT), microcontroller, sensors, identification system, automated lid system, display system, communication system, liquid crystal display (LCD), waste monitoring, garbage level measurement, Global System for Mobile Communications (GSM) module

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INTRODUCTION

The concept of a smart dustbin for household using internet of things (IoT) revolves around employing modern technology to enhance the management and monitoring of household waste. Here is a detailed exploration of how such a system works and its benefits [1]:

Components and Working

Sensors

Ultrasonic Sensors

These sensors are commonly used to measure the distance between the top of the trash in the bin and the lid. They work by emitting ultrasonic waves and

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calculating the time it takes for the waves to bounce back after hitting an object, thereby determining the fill level of the bin.

Weight Sensors

Alternatively, weight sensors can be used to measure the weight of the garbage directly. This provides a more accurate measurement of the fill level and can trigger alerts when a certain weight threshold is reached [2].

Microcontroller

Devices like Arduino or ESP32 serve as the brain of the smart dustbin system. They receive data from the sensors and process it to determine the fill level. They also manage communication protocols to send alerts or notifications to users or authorities [3].

Connectivity

- *Wi-Fi or Global System for Mobile Communication (GSM) Module:* These modules enable the dustbin to connect to the internet, allowing real-time data transmission. Wi-Fi is suitable for urban areas where internet connectivity is robust, while GSM modules provide connectivity even in remote locations.
- *Bluetooth:* In some cases, Bluetooth connectivity may be used for local communication between the dustbin and a nearby smartphone or gateway device [4].

User Interface

- *Mobile App or Web Interface:* Users can monitor the fill level of the dustbin remotely through a dedicated mobile app or web portal. The interface displays real-time data and sends alerts when the dustbin is full, facilitating timely waste collection [5].

Alert Mechanisms

- *Buzzer or Light Emitting Diode (LED) Indicators:* These are integrated into the dustbin to provide local alerts. For instance, a buzzer may sound when the dustbin reaches its capacity, or LED lights may change color to indicate different fill levels (e.g., green for empty, yellow for nearing full, red for full) [6].

Benefits

Efficient Waste Management

- The system optimizes waste collection routes by notifying authorities when bins are full, reducing unnecessary trips and operational costs.
- It prevents overflow, which can lead to littering and environmental pollution [3].

Convenience for Users

- Residents can check the status of dustbins remotely, ensuring they only dispose of waste when there is sufficient space available.
- It encourages responsible waste disposal practices among users [7].

Environmental Impact

- Effective waste management contributes to a cleaner environment by reducing the risk of diseases, pests, and odors associated with overflowing garbage.
- Smart segregation of waste (future enhancement) can further improve recycling rates and reduce landfill waste [8].

Data Analytics and Insights

- The system generates data on waste generation patterns and fill rates, which can be analyzed to optimize waste management strategies and resource allocation.

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- Insights from data analytics help municipalities plan for future waste management infrastructure and services [9].

Future Enhancements

Artificial Intelligence and Machine Learning

- Implementing artificial intelligence (AI) algorithms can improve waste segregation by automatically identifying recyclable materials or organic waste.
- Machine learning models can predict fill levels based on historical data, improving efficiency in waste collection schedules [10].

Integration with Smart City Initiatives

- Smart dustbins can be integrated into broader smart city frameworks, allowing for seamless coordination between various urban services like transportation, energy management, and public safety [11].

Environmental Sensors

- Adding sensors to monitor air quality or temperature within the vicinity of the dustbin can provide additional environmental insights.

Community Engagement

- Involving residents in waste management through educational campaigns or incentives linked to responsible waste disposal practices.

The implementation of smart dustbins using IoT holds significant promise in transforming urban waste management into a more efficient, sustainable, and technology-driven process. By leveraging IoT capabilities, cities can address environmental challenges while improving overall quality of life for residents [12].

To ensure sustainable development, proper waste disposal is crucial. Open dumping and scavenging at dumpsites pose serious health risks such as skin infections and chronic diseases. IoT refers to the network of physical objects embedded with sensors, software, and other technologies that exchange data over the internet.

In this project, we propose a system for immediate dustbin cleaning. Using ultrasonic sensors, the system detects when bins reach capacity, triggering timely emptying. Currently, overflowing bins are common due to daily waste accumulation, leading to unpleasant odors and unsanitary conditions that promote disease spread. Proper waste management is essential as the global population grows, ensuring clean and hygienic environments for healthier lives.

IoT enables devices to connect and exchange data, making traditional objects “smarter” by facilitating internet connectivity and communication between devices and people. IoT ecosystems consist of smart devices with embedded systems like processors and sensors, collecting and sharing data. This data is either analyzed locally or sent to the cloud via IoT gateways. IoT's integration with AI and machine learning enhances data collection and processing, aiding in dynamic decision making.

Smart dustbins for households leverage IoT technology to monitor fill levels and ensure prompt cleaning. These bins use ultrasonic sensors on their lids to detect garbage levels, preventing overflow and maintaining cleanliness. The integration of AI in waste management, such as predicting bin fill patterns and optimizing collection schedules, enhances efficiency and sustainability.

Research at the University of South Australia exemplifies AI's role in waste management, using smart bin sensor data to predict waste accumulation and optimize collection routes. This approach improves

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efficiency in waste services, addressing environmental and health concerns associated with improper waste management.

In conclusion, IoT-driven smart dustbins enhance waste management efficiency, ensuring cleaner environments and healthier communities. This technology not only automates processes but also provides valuable insights for better resource allocation and environmental sustainability.

METHODOLOGY

After reviewing various existing garbage monitoring systems, this smart household dustbin proposal incorporates the use of ESP32 and ultrasonic sensors. The system monitors garbage levels within the dustbin (Figures 1–9).

The smart dustbin for household utilizes the following components:

1. *ESP32 Microcontroller:* Provides Wi-Fi and Bluetooth connectivity.
2. *Breadboard:* Used for circuit prototyping and testing.
3. *Connecting Wires:* Connect sensors to the breadboard.
4. *Buzzer:* Used for alerts.

The block diagram (Figure 1) illustrates the system's architecture. An ultrasonic sensor measures the garbage bin's fill level, with data processed by the ESP32 for Wi-Fi transmission. Data is displayed on the Arduino IDE's serial monitor.

The flow diagram (Figure 2) shows how the system monitors garbage levels and communicates the status to users.

The sequence diagram (Figure 3) illustrates the interactions between system components to achieve specific outcomes.

The Level 0 data flow diagram (Figure 4) outlines the overall flow of data within the system, identifying external entities, data flows, processes, and data stores.

The Level 1 data flow diagram (Figure 5) provides a more detailed view of specific processes and data flows within the system.

An infrared (IR) sensor detects infrared radiation emitted by objects, providing proximity sensing capabilities (Figure 6).

A servo motor controls shaft position based on pulse width modulation (PWM) signals, useful for mechanical adjustments in various applications (Figure 7).

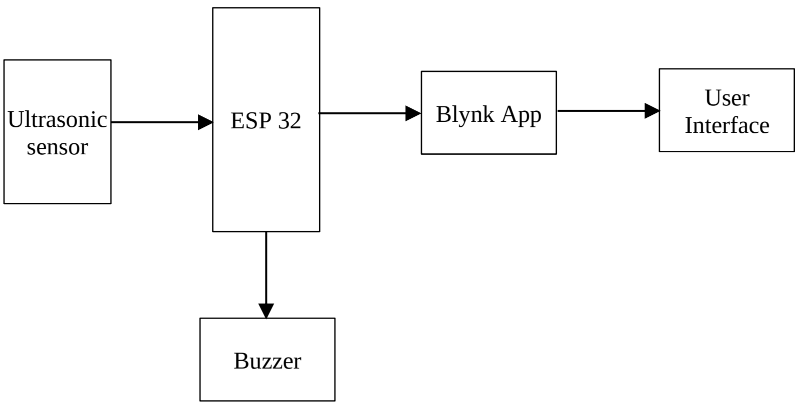

Figure 1. Block diagram.

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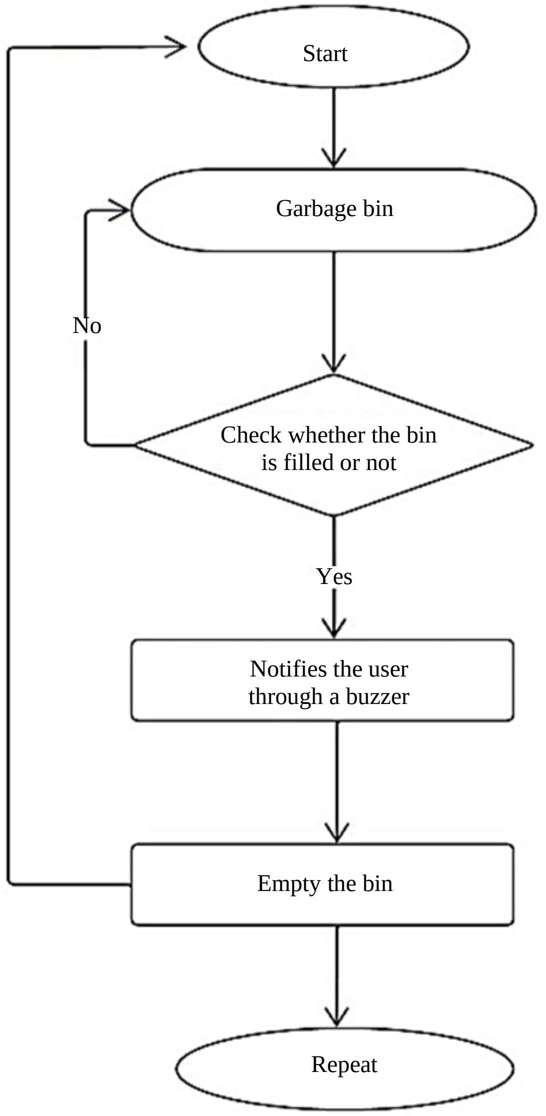

Figure 2. Flow diagram.

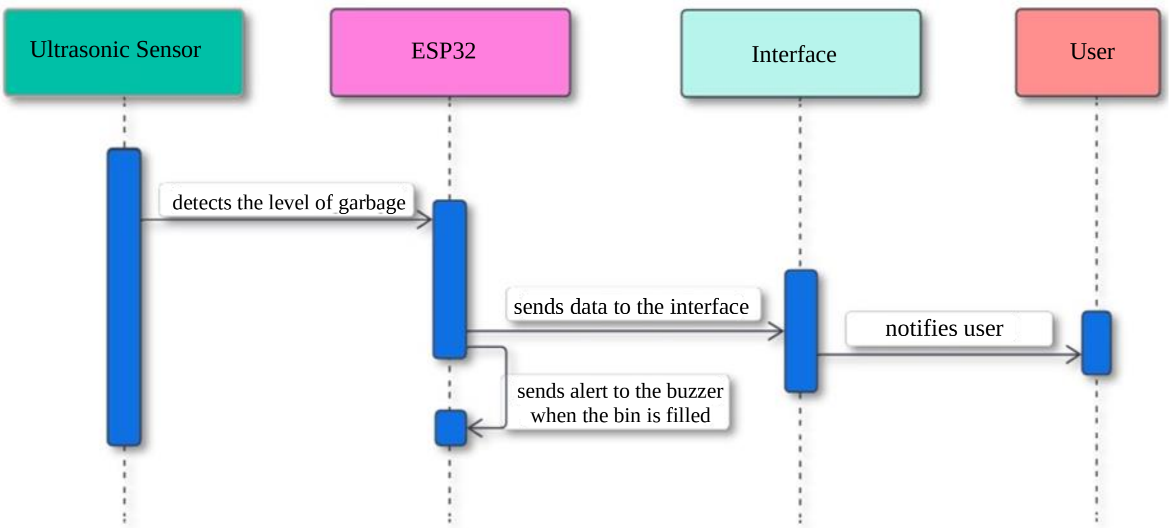

Figure 3. Sequence diagram.

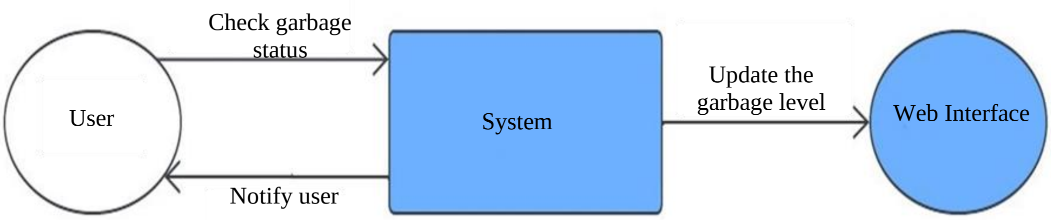

Figure 4. Level 0 data flow diagram.

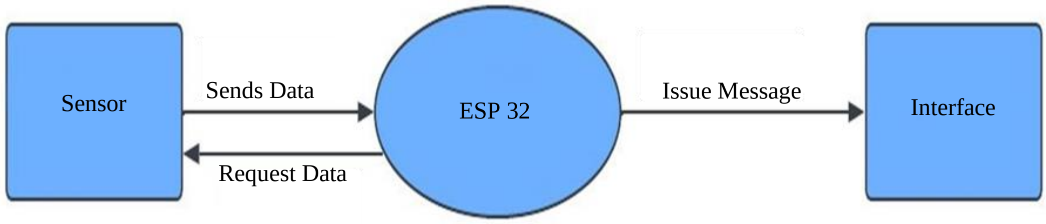

Figure 5. Level 1 data flow diagram.

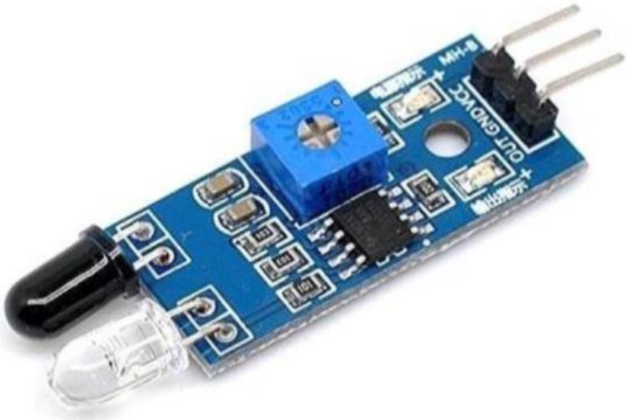

Figure 6. Infrared sensor.

Figure 7. Servo motor.

The SIM800L GSM module facilitates GPRS transmission, SMS communication, and voice calls, suitable for long-range connectivity projects Figure 8.

Each component plays a crucial role in enhancing the functionality of the smart dustbin for household, contributing to efficient waste management and smart monitoring capabilities.

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Figure 8. SIM800L GSM module.

Figure 9. Ultrasonic sensor (HC-SR04).

SYSTEM REQUIRMENTS

To implement our project, the following hardware components are essential:

Ultrasonic Sensor (HC-SR04)

The HC-SR04 uses ultrasonic sound waves to measure distances. It includes pins for VCC (power), Trigger (input), Echo (output), and Ground (GND) (Figure 9 and Table 1).

- *VCC:* Powers the sensor (typically +5 V).
- *Trigger:* Input pin for sending ultrasonic pulses.
- *Echo:* Output pin for receiving reflected pulses.
- *GND:* Ground connection.

ESP32 Microcontroller

- Developed by Espressif Systems, the ESP32 offers Wi-Fi and Bluetooth capabilities. It features a Tensilica Xtensa LX6 dual-core processor with speeds up to 240 MHz (Figure 10).

Functional Blocks of ESP32

- *Wireless Connectivity:* Supports Wi-Fi 802.11 b/g/n (2.4GHz) and Bluetooth v4.2/BLE.
- *Core:* Dual-core Xtensa processors for efficient performance.
- *Memory:* Includes program memory, SRAM, and EEPROM.
- *Encryption Accelerators:* AES, SHA, RSA for enhanced security.

Table1. Pin number and function of ultrasonic sensor.

	Pin Number	Description
1	VCC	The VCC pin powers the sensor, typically with +5 V.
2	Trigger	Trigger pin is an input pin.
3	Echo	Echo pin is an output pin.
4	GND	This pin is connected to the ground of the system.

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Jumper Wires
- Used for connecting various components without soldering. It is ideal for prototyping and circuit testing (Figure 11).

Buzzer
- Produces audible alerts based on input frequency. It requires 3.3 to 5 V for operation (Figure 12).

Breadboard
- A prototyping board with interconnected spring clips beneath its surface. It facilitates easy circuit assembly and modification (Figure 13).

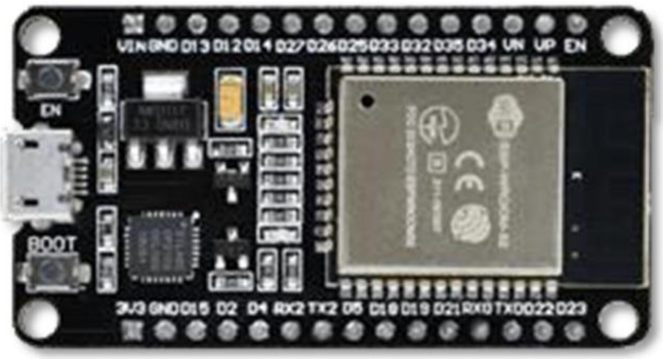

Figure 10. ESP32 microcontroller.

Figure 11. Jumper wires.

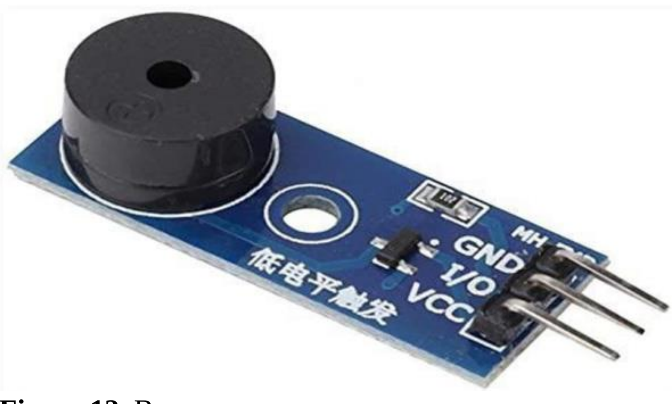

Figure 12. Buzzer.

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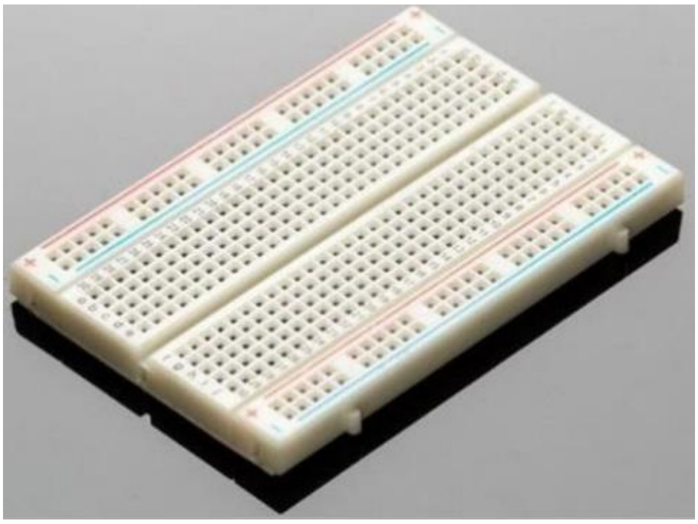

Figure 13. Breadboard.

Dustbin

- Standard household dustbin used for waste collection.

Software Requirements

- *Arduino IDE:* Open-source software for writing, compiling, and uploading code to Arduino-compatible boards. It supports Windows, MacOS, and Linux (Figure 14).

Blynk Platform

- Allows creation of interfaces for hardware projects on iOS and Android devices.
- Enables communication between smartphones and hardware via widgets like buttons, sliders, and graphs.

This setup utilizes the ESP32 microcontroller along with sensors and peripherals to create a smart dustbin system capable of monitoring garbage levels and transmitting data via Wi-Fi or Bluetooth for efficient waste management.

RESULTS AND DISCUSSION

Undertaking this project provided us with valuable insights into IoT, demonstrating how physical objects equipped with sensors, processors, and connectivity technologies can interact and share data over the internet. In today's fast-paced world, where time is often scarce, waste disposal can be neglected, leading to health hazards and environmental issues. The primary goal of our smart dustbin for household system using IoT is to minimize manual monitoring efforts and resource usage.

Our system employs an ultrasonic sensor for distance measurement and a buzzer to alert users when the dustbin reaches capacity. Building upon existing systems, our project introduces advanced features such as mapping functionalities and automatic lid locking with remote access. Mapping technology, crucial in navigation and logistics, aids in locating dustbins efficiently and enables swift responses from authorities.

The automatic locking mechanism prevents overflow and curtails unpleasant odors in the vicinity. To notify users effectively, we utilize LED indicators—green when the dustbin is empty and red when full—ensuring clear visibility for all users, regardless of literacy level. Additionally, for centralized monitoring and management, we implemented a graphical user interface (GUI) accessible via a website or mobile app. This GUI provides real-time updates on garbage levels and locations, enhancing operational efficiency.

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Figure 14. Arduino IDE (integrated development environment).

In our project, we leverage the Blynk application for IoT, facilitating remote connectivity via smart phones' Wi-Fi connections without additional hardware modules. To integrate our project with the Blynk platform, drivers and libraries must be installed in the Arduino IDE. Begin by downloading the required drivers, such as those for Intel Curie boards, through the Arduino IDE's Boards Manager under Tools. Then, install necessary libraries like WiFi101, Blynk, and Ultrasonic via the Library Manager under Sketch > Include Libraries.

By adhering to these steps, our smart dustbin for household system not only improves waste management efficiency but also promotes environmental hygiene and resource conservation through IoT innovation.

CONCLUSION

The proposed “Smart Dustbin for Household using IoT” system offers a solution to prevent garbage overflow effectively. Many individuals, particularly those in the workforce, lead busy lives and struggle to find time for disposing of waste. This IoT-based dustbin enables users to monitor waste levels and ensure timely disposal, thereby maintaining cleanliness and fostering a healthier environment. By managing waste efficiently, it helps mitigate health risks associated with improper waste disposal.

The application of IoT in managing household waste represents a significant technological advancement that simplifies daily life. This project not only promotes cleanliness but also monitors the performance of local authorities in waste management. By alerting authorities when bins are full and providing location data via maps, it reduces the frequency of garbage collection trips and associated costs. The use of LED indicators (red and green) ensures that all users, regardless of literacy level, can easily determine the status of the dustbin.

Moreover, this system contributes to animal welfare by preventing domestic animals from consuming harmful materials like plastics. Overall, it aims to create a cleaner environment through efficient waste management.

Future Scope

To further enhance this system, an automated solution could be developed to monitor garbage levels more accurately, collect and segregate waste into appropriate bins automatically. Future enhancements could include implementing multiple bins that automatically sort waste based on type into designated color-coded compartments, thereby optimizing waste segregation. This project could evolve further by enhancing connectivity and communication among dustbins using IoT technology.

Innovative features such as incorporating moisture sensors to segregate liquid waste, decomposable waste, and non-decomposable waste within larger bins can also streamline waste management processes. By continuously improving and refining these technologies, we can achieve more effective waste management and contribute to a cleaner and healthier environment.

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Numerous studies have explored the implementation of IoT technology in smart garbage monitoring systems, highlighting its role in enhancing urban sustainability and cleanliness. These systems leverage sensors and connectivity to monitor waste levels in real time, facilitating timely collection and reducing environmental and health hazards associated with improper waste management.

The "Smart Dustbin for Household Using IoT" addresses the practical challenges faced by urban dwellers in managing waste efficiently. By employing IoT devices like sensors and microcontrollers, the system offers a proactive approach to waste management, alerting authorities or users when bins reach capacity. This not only optimizes garbage collection schedules but also promotes a cleaner environment by preventing overflow and associated littering.

Moreover, advancements in these systems include features like automated lid locking mechanisms and real-time data visualization through mobile applications or web interfaces. Such enhancements improve user interaction and operational efficiency, ensuring that municipal resources are utilized effectively.

Future developments could focus on integrating AI algorithms for more precise waste segregation and optimizing collection routes based on dynamic data analysis. These innovations aim to further streamline urban waste management processes and contribute to sustainable city living.

REFERENCES

1. Khan IR, Alam M, Razdan A. Smart garbage monitoring system using IoT. In: 2nd International Conference on Emerging Trends in Mathematical Sciences & Computing (IEMSC-21), Kolkata, India, February 5–7, 2021. SSRN Electronic Journal. Available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3902056
2. Sohag MU, Podder AK. Smart garbage management system for a sustainable urban life: an IoT based application. Internet of Things. 2020; 11: 100255.
3. Murugaanandam S, Ganapathy V, Balaji R. Efficient IoT based smart bin for clean environment. In: 2018 International Conference on Communication and Signal Processing, Chennai, India, April 3–5, 2018. pp. 2045–2048.
4. Nehete P, Jangam D, Barne N, Bhoite P, Jadhav S. Garbage management using internet of things. In: 2018 International Conference on Electronics, Communication and Aerospace Technology (ICECA), Coimbatore, India, March 29–31, 2018. pp. 1476–1480.
5. Anitha A. Garbage monitoring system using IoT. IOP Conf Ser Mater Sci Eng. 2017; 263 (4): 042027.
6. Panjabi M, Patel K. Digital dustbin – smart bins for smart cities. Int J Innov Technol Exploring Eng. 2020; 9 (7S): 60–65.
7. Chaware SM, Dighe S, Joshi A, Bajare N, Korke R. Smart garbage monitoring system using internet of things (IoT). Int J Innov Res Electric Electron Instrum Control Eng. 2017; 5 (1): 74–77.
8. Sinha T, Mugesh K. Smart dustbin. Int J Indus Electron Electric Eng. 2019;7 (3): 16–19.
9. Nagaraju U, Mishra R, Kumar C, Rajkumar. Smart Dustbin for Economic Growth. Project Report. Vellore, India: VIT University; 2017.
10. Parikh P, Vasani R, Rava A. Smart dustbin: An intelligent approach to fulfill Swatchh Bharat Mission. Int J Eng Res Electron Commun Eng. 2019; 6 (4): 92–96.
11. Sundarakumar MR, Naveen S, Arun Kumar S, Ray KK. Smart dustbin – garbage monitoring system by efficient Arduino based. In: Proceedings of the International Conference on Intelligent Computing Systems, Salem, India, December 15–16, 2017.. pp. 165–167.
12. Yusof NM, Zulkifli MF, Mohd Yusof NYA, Azman AA. Smart waste bin with real-time monitoring system. Int J Eng Technol. 2018; 7 (4): 2186–2190.

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